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(E76-10275) COFFEE INVENTORY THROUGH ORBITAL IMAGERY (Coffee Institute, Rio de Janeiro (Brazil).) 19 p HC $3.50 CSCL 02C
N76-21642
Unclas
G3/43 00275

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GRUPO EXECUTIVO DE RACIONALIZAÇÃO DA CAFEICULTURA
SERVIÇO DE FOTOINTERPRETAÇÃO
RUA MIGUEL PEREIRA, 55, HUMAITÁ, ZC-02
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SR Nº 525

COFFEE INVENTORY THROUGH ORBITAL IMAGERY

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TYPE III Report for Period July 1973-December 1974

Brazilian Coffee Institute - GERCA
Rua Miguel Pereira, 55 - Humaitá
20.000 - Rio de Janeiro
BRAZIL

1. SR Nº
525

2. Type of Report
III

3. Recipient's Catalog Nº

4. Title
COFFEE INVENTORY THROUGH ORBITAL IMAGERY

5. Report Date
December 1974

6. Period Covered
July 1973-December 1974

7. Principal Investigator
MARCOS HENRIQUE VELLOSO

8. Nº of Pages 20

9. Name and Address of Principal Investigator's Organization
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10. Principal Investiga. Rept. Nº 1

11. GSFC Technical Monitor
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12. Sponsoring Agency Name and Address
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Rua Miguel Pereira, 55 - Humaitá
20.000 - Rio de Janeiro - Brazil

13. Key Words

COFFEE INVENTORY

14. Supplementary Notes

To be published in English and Portuguese

15. Abstract

This report describes the use of MSS orbital imagery obtained by ERTS1 satellite for the purpose of coffee inventory through visual photointerpretation. The results in terms of areas occupied with coffee, is then compared with the Coffee Inventory (Situation 1971/1972), in which conventional photointerpretation was used on black and white photographs and photoindices at scales of 1:25 000 and 1:100 000 respectively.

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COFFEE INVENTORY THROUGH ORBITAL IMAGERY

INTRODUCTION

The Brazilian Coffee Institute (IBC) through its Photointerpretation Service of the Executive Group of Racionalization of the Coffee Culture has, since 1967, carried out surveys of physical aspects of - coffee plantations.

These surveys have been based on conventional aerial photographs, and have included inventories for the examination of an important parameter: the increase or decrease of the coffee area.

To be able to carry out inventories at more frequent intervals, without the high cost of conventional photographic flights the IBC presented a research proposal to the National Aeronautics and Space Administration-NASA to test the viability of the imagery obtained by the ERTS-1 satellite for the above-mentioned inventories and, depending on the results, to become an user of such imagery.

OBJECTIVES

The following objectives oriented the research:

1 - To test the viability of interpretation of the imagery - taken from the ERTS-1 satellite for the purpose of obtaining information on areas occupied with coffee plantations and the introduction of contour planting (as oposed to the standard square-planting technique).

This information would indicate variations in the area and techniques of planting and therefore reflect production.

2 - To verify which MSS sensor channel or channel combinations would permit the best identification of coffee plantations.

3 - To verify the season in which coffee plantations are more easily identified.

SURVEYED AREA

In accordance with the proposal presented to NASA the research- was based on interpretation and comparison of the following frames which include part of the proposed area (between the latitude 22°00' and - 23°00' S and longitude 51°00' and 52°00' W Gr.): frame numbers 1123 - 12510 of November 23,1972;1213-12511 of February, 21,1973 and 1231-12512 of March, 11,1973.

MATERIAL USED IN THE RESEARCH

The MSS images used in the research correspond to bulk type.

1 - Black and white transparencies, format 237,5mmx237,5mm (9.5x9.5 inches), of the imagery obtained by the MSS sensor.

2 - Black and white printed copies of all channels and their combinations.

3 - Color transparencies of each channel obtained with filters.

4 - Color composition transparencies obtained by superposition of the channel color transparencies.

5 - Color composition printed copies.

6 - Thematic map of the São Paulo State Coffee Inventory - Situation 1971/1972.

7 - Dot grid in which each dot represents 64ha in the 1: 1 000 000 scale.

8 - Black and white conventional photographs of scale - 1:25 000 taken in 1971/1972 (Fig. 1).

9 - Photoindices in the scale 1:100 000, related to the photogrametric survey from which resulted the above-mentioned photographs.

10 - Light table.

METHODOLOGY

It was intended to study an area that represented a reasonable degree of interpretation difficulty. Depending on the results obtained in this area, the same procedure would be extended to all coffee region of São Paulo, Paraná, Minas Gerais and Espírito Santo States.

The following steps show how the work was conducted.

1 - Selection of the channels or their combination, which best correlate with photographs, in scale 1:25 000 and photoindices of scale 1:100 000 taken in 1971/1972.

2 - Division of the ERTS image and the Coffee Inventory map (Situation 1971/1972) into 9 sectors. This was made considering the variation of the coffee crop pattern in the ERTS image.

3 - Coffee plantations mapping on ERTS images by 3 photointerpreters, independently and based on a specific pattern for each sector when it was possible.

4 - Production of one map, resulting from the intersection of the photointerpreter's maps and measurement of the area occupied with coffee using dot grid.

5 - Comparison of the results obtained on the ERTS image and those of Coffee Inventory's map.

The interpretation of black and white material was made on printed copies, while for color material (transparencies) use was made of a ligth table.

Printed copies and transparencies on ligth table were chosen after comparison with the results using I^2S viewer (belonging to the Space Research Institute) which showed absence of a significant difference between the two methods.

RESULTS AND CONCLUSIONS

Tables nº 1 to 6 show the results in terms of area, obtained - by both the Coffee Inventory and the interpretation of the MSS best channel or channel combination. In case of black and white images, the sums on the top of the tables represent the combinations of the MSS channels. For color composition, each number of the parcel is followed by a letter C, Y or M. This letter represents the filter used in each channel. Thus, C, Y and M mean respectively, cyan, yellow and magenta filter. These same tables, also present the percentual errors obtained. Table nº 7 permits a comparison of the accuracy of black and white and color material as well as the epochs that the images were taken.

As can be seen in tables 1 to 7, the percentages of error are generally too much high. The imagery taken in November presents the least percentage of error, for black and white as well as for color material. The reason seems to be mainly the stage of the annual and inter-row crops during this epoch resulting in a low soil coverage and thus reducing the variation of the image pattern for the coffee culture in each sector.

The channel combination that permits least error is 4+6+7(November, 1972), for both black and white (Fig. 2) and color material(Fig.-3). The filters used in this color composition were: channel 4 (cyan-filter), channel 6 (magenta filter) and channel 7 (yellow filter).

The scene's sectors 4 and 5 showed the best accuracy in almost all the material interpreted. This can be explained by the continuous-areas of the coffee plantations of several farms located in that region.

On the other hand, the other sectors presented a very low accuracy due to the isolated characteristics of coffee plantations in these sectors.

The use of color composition, for this specific purpose, did not improve the quality of the results.

Concerning the use of MSS images for the proposed aims the following observations can be made:

System Resolution is one of the most important factors limiting the identification of the coffee plantations. Considering that the images received from the MSS sensor of the ERTS-1 satellite, have a resolution of about 130m and that the average spacing between the coffee trees is about 3,30m, (with about 40% of soil coverage) it is evident that each image resolution unit contain in conjunction the registers of reflected radiaton from soil and vegetation.

The heterogeneity of soil, a factor that occurs throughout the coffee region, including the test area selected, cause differences in radiation reflections between contiguous areas, which is increased by the heterogeneity of soil moisture levels that exist over extensive areas. These factors combined with variations in coffee spacing and sizes of individual coffee trees result in large variations in observed multispectral signatures of the coffee crop. In other words a single ERTS image possesses areas of coffee with very different signatures. Further, several different types of ground cover produce the same image patterns and signatures.

The atmospheric absorption, emission and scattering radiation effects, which cause image intensity and contrast alterations of targets located on the earth's surface are well known. Considering the haze intensity variation that occurs when extensive areas are observed, it seems to us that this fact together with the above-mentioned, causes the extreme difficulty in the determination of image patterns for coffee plantations and the impossibility of separating square from contour planting techniques.

TABLE CAPTIONS

Table nº 1 - Black & white image (November 1972). Results expressed as area estimates and percentage (error) deviation from Coffee Inventory estimates of 1971/1972.

Table nº 2 - Color composition image (November 1972). Results expressed as area estimates and percentage (error) deviation- from Coffee Inventory estimates of 1971/1972.

Table nº 3 - Black & white (February 1973). Results expressed as area estimates and percentage (error) deviation from Coffee - Inventory estimates of 1971/1972.

Table nº 4 - Color composition image (February 1973). Results expressed as area estimates and percentage (error) deviation- from Coffee Inventory estimates of 1971/1972.

Table nº 5 - Black & white image (March 1973). Results expressed as area estimates and percentage (error) deviation from Coffee Inventory estimates of 1971/1972.

Table nº 6 - Color composition image (March 1973). Results expressed- as area estimates and percentage (error) deviation from Coffee Inventory estimates of 1971/1972.

Table nº 7 - General results expressed as percentage (error) deviation from Coffee Inventory estimates of 1971/1972.

FIGURE CAPTIONS

Figure 1 - Black & white conventional photograph of scale 1:25.000 showing some mapped coffee plantations.

Figure 2 - Black & white photograph of ERTS-1 showing mapped coffee - plantations.

Figure 3 - Color composition photograph of ERTS-1 showing mapped cof - fee plantations.

SECTOR	INVENTORY 71/72 AREA Km².	CHANNELS								MEAN ERROR %
		4		4+5+6		4+6+7		4+5+6+7		
		AREA Km².	ERROR %	AREA Km².	ERROR %	AREA Km².	ERROR %	AREA Km².	ERROR %	
1	114.0	0.0	100.0	0.0	100.0	4.5	96.1	0.0	100.0	99.0
2	42.0	1.9	95.5	0.0	100.0	13.4	68.1	0.0	100.0	90.9
3	72.0	0.0	100.0	0.0	100.0	3.8	97.4	0.0	100.0	99.4
4	368.0	283.5	23.0	325.0	11.5	352.6	4.2	390.4	6.1	11.2
5	496.0	192.6	61.2	122.2	75.4	179.2	63.9	152.3	69.3	67.5
6	206.0	0.0	100.0	15.4	92.5	313.6	52.2	4.5	97.8	85.6
7	58.0	14.1	75.7	1.3	97.8	21.1	63.6	4.5	92.3	82.4
8	58.0	2.6	95.5	0.0	100.0	3.2	94.5	0.0	100.0	97.5
9	212.0	2.6	98.8	0.0	100.0	21.8	89.7	3.8	98.2	96.7
MEAN ERROR %			83.3		86.4		70.0		84.9	81.1

TABLE Nº 1. - Black & white image (November 1972). Results expressed as area estimates and percentage (error) deviation from Coffee Inventory estimates of 1971/1972.

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SECTOR	INVENTORY 71/72 AREA Km^2	C H A N N E L S										MEAN ERROR %
		5(Y+C)+7(y+M)		5C+6M+7Y		6M+5Y+4C		5(Y+C)+6(Y+M)		6M+4C+7Y		
		AREA Km^2	ERROR %	AREA Km^2	ERROR %	AREA Km^2	ERROR %	AREA Km^2	ERROR %	AREA Km^2	ERROR %	
1	114.0	0.0	100.0	1.9	98.3	11.5	89.9	1.9	98.3	35.0	69.3	91.2
2	42.0	15.4	63.3	2.9	93.1	0.0	100.0	0.0	100.0	12.0	71.4	85.6
3	72.0	0.0	100.0	0.0	100.0	0.0	100.0	0.0	100.0	0.0	100.0	100.0
4	368.0	588.2	59.8	334.7	9.1	589.4	60.2	474.9	29.1	630.5	71.3	45.9
5	496.0	352.0	29.0	182.1	63.3	372.8	24.8	227.8	54.1	568.5	14.6	37.2
6	206.0	29.4	85.7	32.0	84.5	9.3	95.5	10.9	94.7	47.5	76.9	87.5
7	58.0	0.0	100.0	3.8	93.5	2.6	95.5	0.0	100.0	0.0	100.0	97.8
8	58.0	10.2	82.4	2.2	96.2	4.8	91.7	4.5	92.2	4.5	92.2	90.9
9	212.0	39.0	81.6	28.2	86.7	28.8	86.4	27.2	87.2	53.0	75.0	83.4
MEAN ERROR %			78.0		80.5		82.7		84.0		74.5	79.9

TABLE Nº 2 - Color composition image (November 1972). Results expressed as area estimates and percentage (error) deviation from Coffee Inventory estimates of 1971/72.

		CHANNELS								
		5		4 + 5		5 + 6		4 + 5 + 6		
SECTOR	INVENTORY 71/72 AREA Km²	AREA Km²	ERROR %	AREA Km²	ERROR %	AREA Km²	ERROR %	AREA Km²	ERROR %	MEAN ERROR %
1	114.0	0.0	100.0	0.0	100.0	0.0	100.0	0.0	100.0	100.0
2	42.0	0.0	100.0	0.0	100.0	0.0	100.0	0.0	100.0	100.0
3	72.0	0.0	100.0	0.0	100.0	0.0	100.0	0.0	100.0	100.0
4	368.0	170.0	53.6	259.8	29.4	257.9	29.9	265.0	28.0	35.2
5	496.0	62.7	87.4	73.0	85.3	68.5	86.2	74.9	84.9	86.0
6	206.0	2.6	98.7	5.8	97.2	2.6	98.7	2.9	98.6	98.3
7	58.0	0.0	100.0	0.0	100.0	0.0	100.0	0.0	100.0	100.0
8	58.0	0.0	100.0	3.8	93.4	1.9	96.7	1.3	97.8	97.0
9	212.0	9.6	95.5	11.5	94.6	7.7	96.4	5.8	97.3	96.0
MEAN ERROR %			92.8		88.9		89.8		89.6	90.3

TABLE 3 - Black & white image (February 1973). Results expressed as area estimates and percentage (error) deviation from Coffee Inventory estimates of 1971/1972.

SECTOR	INVENTORY 71/72 AREA Km²	CHANNELS										MEAN ERROR %
		5(Y+C)+7(Y+M)		5C+6M+7Y		6M+5Y+4C		5(Y+C)+6(Y+M)		6M+4C+7Y		
		AREA Km²	ERROR %	AREA Km²	ERROR %	AREA Km²	ERROR %	AREA Km²	ERROR %	AREA Km²	ERROR %	
1	114.0	0.0	100.0	0.0	100.0	0.0	100.0	0.0	100.0	0.0	100.0	100.0
2	42.0	0.0	100.0	0.0	100.0	0.0	100.0	0.0	100.0	0.0	100.0	100.0
3	72.0	0.0	100.0	0.0	100.0	0.0	100.0	0.0	100.0	0.0	100.0	100.0
4	368.0	231.0	37.2	253.4	31.1	250.2	32.0	218.6	40.6	202.9	44.9	37.2
5	496.0	80.6	83.8	69.1	86.1	75.5	84.8	96.0	80.6	38.4	92.3	85.5
6	206.0	9.0	95.6	8.3	96.0	9.0	95.6	5.4	97.4	5.4	97.4	96.4
7	58.0	0.0	100.0	0.0	100.0	0.0	100.0	0.0	100.0	0.0	100.0	100.0
8	58.0	0.0	100.0	0.0	100.0	0.0	100.0	0.0	100.0	0.0	100.0	100.0
9	212.0	3.8	98.2	7.4	96.5	4.5	97.9	4.8	97.7	3.2	98.5	97.8
MEAN ERROR %			90.5		90.0		90.0		90.7		92.6	90.8

TABLE Nº 4 - Color composition image (February 1973). Results expressed as area estimates and percentage (error) deviation from Coffee Inventory estimates of 1971/72.

SECTOR	INVENTORY 71/72 AREA Km².	CHANNELS								
		4		5		4 + 5		4 + 5 + 6		MEAN ERROR %
		AREA Km².	ERROR %	AREA Km².	ERROR %	AREA Km².	ERROR %	AREA Km².	ERROR %	
1	114.0	0.0	100.0	0.0	100.0	0.0	100.0	0.0	100.0	100.0
2	42.0	0.0	100.0	0.0	100.0	0.0	100.0	0.0	100.0	100.0
3	72.0	0.0	100.0	0.0	100.0	0.0	100.0	0.0	100.0	100.0
4	368.0	288.0	21.7	226.9	38.3	252.8	31.3	341.1	7.3	24.7
5	496.0	86.4	82.6	63.4	87.2	73.6	85.2	103.0	79.2	83.6
6	206.0	2.2	98.9	7.7	96.3	2.7	98.7	5.8	97.2	97.8
7	58.0	0.0	100.0	0.0	100.0	0.0	100.0	0.6	99.0	99.8
8	58.0	0.0	100.0	0.0	100.0	0.0	100.0	5.8	90.0	97.5
9	212.0	8.0	96.2	10.9	94.9	7.0	96.7	10.2	95.2	95.8
MEAN ERROR %			88.8		90.7		90.2		85.3	88.8

TABLE Nº 5 - Black & white image (March 1973). Results expressed as area estimates and percentage (error) deviation from Coffee Inventory estimates of 1971/1972.

SECTOR	INVENTORY 71/72 AREA Km²	CHANNELS										MEAN ERROR %
		5(Y+C)+7(Y+M)		5C+6M+7Y		6M+5Y+4C		5(Y+C)+6(Y+M)		6M+4C+7Y		
		AREA Km²	ERROR %	AREA Km²	ERROR %	AREA Km²	ERROR %	AREA Km²	ERROR %	AREA Km²	ERROR %	
1	114.0	0.0	100.0	0.0	100.0	0.0	100.0	0.0	100.0	0.0	100.0	100.0
2	42.0	0.0	100.0	0.0	100.0	0.0	100.0	0.0	100.0	0.0	100.0	100.0
3	72.0	0.0	100.0	0.0	100.0	0.0	100.0	0.0	100.0	0.0	100.0	100.0
4	368.0	219.5	40.4	190.1	48.3	260.8	29.1	193.3	47.5	195.2	47.0	42.5
5	496.0	83.8	83.1	97.9	80.3	105.3	78.8	99.2	80.0	34.6	93.0	83.0
6	206.0	5.1	97.5	5.1	97.5	6.7	96.7	3.5	98.3	3.8	98.2	97.6
7	58.0	0.0	100.0	0.0	100.0	0.0	100.0	0.0	100.0	0.0	100.0	100.0
8	58.0	0.0	100.0	0.0	100.0	0.0	100.0	0.0	100.0	0.0	100.0	100.0
9	212.0	3.2	98.5	1.9	99.1	3.5	98.3	1.3	99.4	1.6	99.2	98.9
MEAN ERROR %			91.1		91.7		89.2		91.7		93.0	91.3

TABLE Nº 6 - Color composition image (March 1973). Results expressed as area estimates and percentage (error) deviation from Coffee Inventory estimates of 1971/72.

Material / Period	Black & White	Color
November (1972)	81.1 %	79.9 %
February (1973)	90.3 %	90.8 %
March (1973)	88.8 %	91.3 %

TABLE Nº 7 - General results expressed as percentage (error) deviation - from Coffee Inventory estimates of 1971/1972.

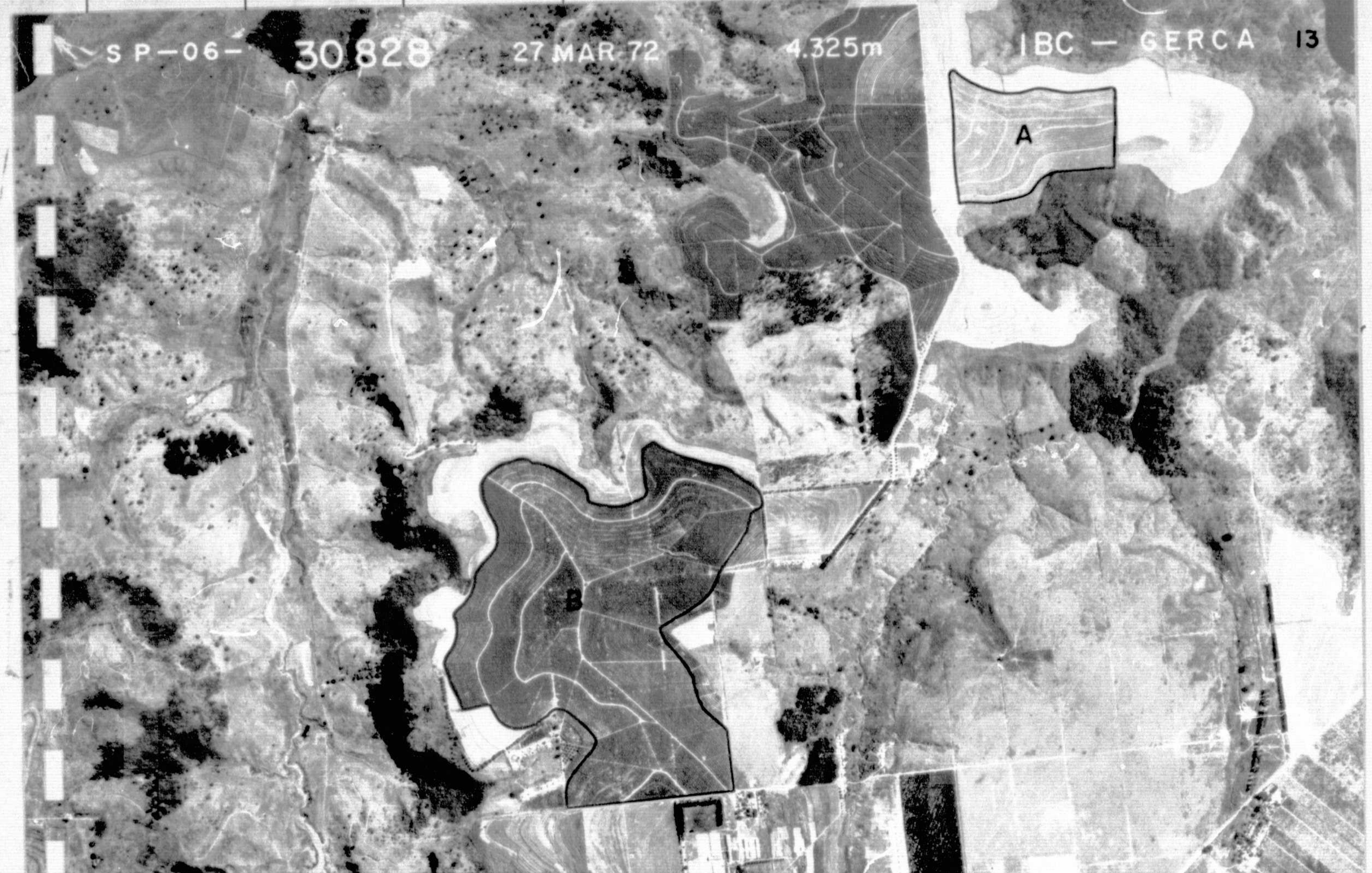
S P-06- 30828 27 MAR 72 4.325m
IBC — GERCA 13
A
B
B
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FIG. 1 – Black & white conventional photograph of scale 1: 25 000 showing some mapped coffee plantations.
A – young coffee B – mature coffee

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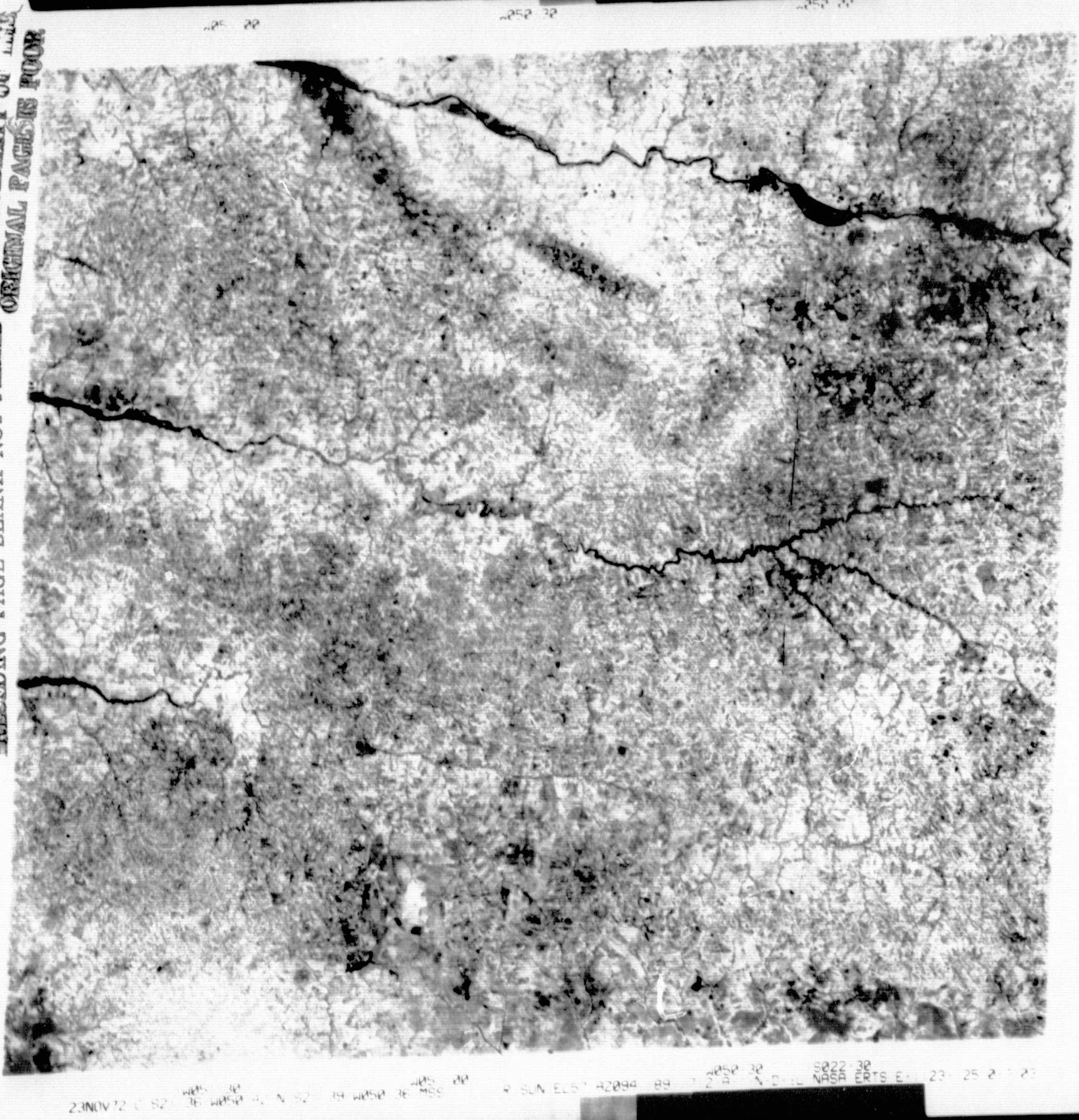
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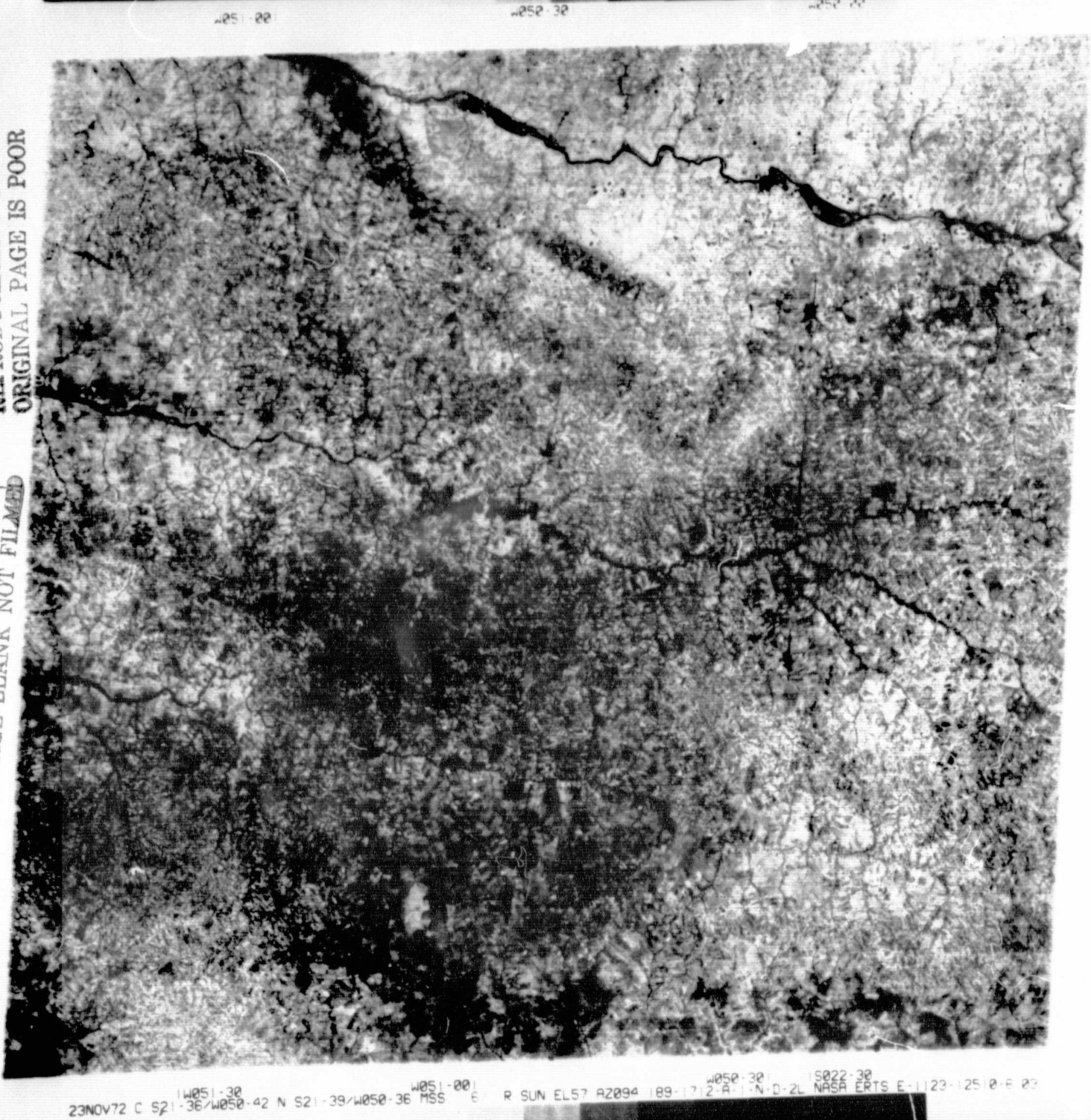
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